Polarity of Organic Compounds

Principles of Polarity:

The greater the **electronegativity** difference between atoms in a bond, the more polar the bond. Partial negative charges are found on the most electronegative atoms, the others are partially positive. In general, the presence of an oxygen is more polar than a nitrogen because oxygen is more electronegative than nitrogen.

The combination of carbons and hydrogens as in hydrocarbons or in the hydrocarbon portion of a molecule with a functional group is always NON-POLAR.

Summary of Polarity
See below for the details.

Polarity Ranking of the Functional Groups:
(most polar first)

Amide > Acid > Alcohol > Ketone ~ Aldehyde > Amine > Ester > Ether > Alkane

An abbreviated list to know well is:

Amide > Acid > Alcohol > Amine > Ether > Alkane

Organic Functional Group Polarity and Electrostatic Potential:

The **molecular electrostatic potential** is the potential energy of a proton at a particular location near a molecule.
Negative electrostatic potential corresponds to: **partial negative charges (colored in shades of red)**.
Positive electrostatic potential corresponds to: **partial positive charges (colored in shades of blue)**.

Boiling Point Definition:

In a liquid the molecules are packed closely together with many random movements possible as molecules slip past each other. As a liquid is heated, the temperature is increased. As the temperature increases, the kinetic energy increases which causes increasing molecular motion (vibrations and molecules slipping pas each other). Eventually the molecular motion becomes so intense that the forces of attraction between the molecules is disrupted to to the extent the molecules break free of the liquid and become a gas. At the temperature of the boiling point, the liquid turns into a gas. The molecules are not in contact each other in the gaseous state.

Polarity and Boiling Point:

The polarity of the molecules determines the forces of attraction between the molecules in the liquid state. Polar molecules are attracted by the opposite charge effect (the positive end of one molecule is attracted to the negative end of another molecule. Molecules have different degrees of polarity as determined by the functional group present.

Principle: The greater the forces of attraction the higher the boiling point or the greater the polarity the higher the boiling point.

	See the table below with the boiling points and the polarity ranking.

Functional Group Ranking by Boiling Points				
R = any number carbons in a hydrocarbon chain *CHIME plug-in required to view these images.				
Functional Group Name	**Boiling Point**	**Polar Rank (most to least)**	**Name**	**Brief Explanation**
Amide	222°	1	ethanamide	(1) AMIDE: Perhaps it is surprising that the amide appears to be the most polar according to the data. The reason is that it can both hydrogen bond and accept hydrogen bonds on both the oxygen and the nitrogen.
Acid	118°	2	ethanoic acid or acetic acid	(2) ACID: These compounds are second in the polarity because of hydrogen bonding capabilities and the presence of two oxygen atoms.
Alcohol	117°	3	propanol	(3) ALCOHOL: These compounds are third in the polarity because of hydrogen bonding capabilities and the presence of only one oxygen vs. the two in the acid functional group.
				(4) KETONE and (5) ALDEHYDE: A comparison of the boiling points

Ketone	56°	4, 5	propanone or acetone	of aldehyde and ketone with the corresponding alcohol shows that the alcohol is more polar due to its ability to hydrogen bond. Since ketones and aldehydes lack hydroxyl groups, they are incapable of intermolecular hydrogen bonds. But due to the presence of the oxygen, they can accept hydrogen bonds from water molecules which account for the complete solubility of low molecular weight compounds. On the other hand, their boiling points are considerable higher than the ether or alkane, indicating the presence of weak intermolecular dipole-dipole forces. The carbonyl group ("carbon double bond oxygen") is polar since oxygen is more electronegative than carbon and forms a partially charged dipole.
Aldehyde	49°	4, 5	propanal	
				(6) AMINE : The polarity of the amine nitrogen is shown to be much less than the oxygen in alcohol

Amine	49°	6	propylamine	group. The nitrogen in the amine is much less electronegative than oxygen in the alcohol. Therefore, the dipole on N-H is much weaker than the dipole on O-H.
Ester	32°	7	methyl ethanoate	(7) ESTER: The ester functional group has a similar character to the ketone and aldehyde functional group. The boiling point indicates that it is the least polar of the three.
Ether	11°	8	methyl ethyl ether	8) ETHER : The carbon-oxygen-carbon bond in ethers is much like the carbon-carbon bond in alkanes. The lack of any oxygen-hydrogen bond makes hydrogen bonding impossible. There is very little intermolecular association. Therefore, the properties of ethers are much like alkanes. Ethers are essentially non-polar and insoluble in water.
Alkane	-42°	9	propane	(9) HYDROCARBON: There is very little intermolecular association because the carbon-hydrogen bond is non-polar. Alkanes,

				alkenes, and alkynes are essentially non-polar and insoluble in water.